HYDROPEDOLOGICAL ASSESSMENT AS PART OF THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS AND WATER USE LICENSE APPLICATION FOR THE PROPOSED EXXARO DORSTFONTEIN WEST MINE EXPANSION, NEAR KRIEL, MPUMALANGA PROVINCE

Prepared for

Nsovo Environmental Consulting

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DOCUMENT GUIDE

The table below provides the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) Regulations 2017 (as amended in 2014) for Specialist Reports and also the relevant sections in the reports where these requirements are addressed.

NEMA Regulations (2017) - Appendix 6	Relevant section in report
(1) A specialist report prepared in terms of these Regulations must contain -	
(a) details of -	
(i) the specialist who prepared the report; and	Appendix D
(ii) the expertise of that specialist to compile a specialist report, including a curriculum vitae;	Appendix D
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix D
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 2
(cB) a description of existing impacts on site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 2
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 2
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying alternative;	Section 4 and 5
(g) an identification of any areas to be avoided, including buffers;	Section 5
(h) a map superimposing the activity, including the associated structures and infrastructure on the environmental sensitivities of the site, including areas to be avoided, including buffers;	Section 5
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.3
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment or activities;	Section 5 and 6
(k) any mitigation measures for inclusion in the EMPr;	Section 5 and 6
(l) any conditions for inclusion in the environmental authorisation;	Section 5 and 6
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 6
(n) a reasoned opinion -	
(i) as to whether the proposed activity, activities or portions thereof should be authorised;	Section 6
(iA) regarding the acceptability of the proposed activity or activities; and	Section 6
(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 6
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report	N/A
(p) a summary and copies, if any, comments received during any consultation process and, where applicable all responses thereto; and	N/A
(q) any other information requested by the competent authority.	No other information requested

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed by Nsovo Environmental Consulting to conduct a hydropedological assessment as part of the Environmental Impact Assessment (EIA) process and Water Use License application for the proposed Exxaro Dorstfontein West Mine Expansion near Kriel, Mpumalanga Province.

The proposed activities entail construction of a conveyor belt and service road connecting the DCM West and DCM East, and an expansion of the discard dump facility which encroaches into the bordering wetlands as well as areas which are terrestrial in nature and comprise mostly of landuses associated to agriculture. Two (2) conveyor route options and associated service roads have been proposed. Thus, it is deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the mining activity areas to ensure that mine planning takes cognizance of the hydropedologically important areas.

According to the wetland assessment conducted by WaterMakers (2019), the study area comprises various wetlands systems, namely:

- Depression wetlands (pan);
- Hillslope Seeps;
- Channeled Valley Bottom wetlands; and
- Unchanneled Valley Bottom wetlands.

According to WaterMakers (2019), the wetland systems have been impacted to some degree, owing to grazing, mining as well as current and historical agricultural activities within the catchment, vegetation clearing, and road infrastructure. Table 5 presents summary results of the Present Ecological State (PES) the wetland systems associated with the proposed development.

Table: Summary results of the Present Ecological State (PES) of the wetlands

HGM Unit	PES Category	HGM Unit	PES Category	HGM Unit	PES Category	HGM Unit	PES Category
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HGM 5	D	HGM 15	D	HGM 25	C	HGM 35	D
HGM 6	C	HGM 16	D	HGM 26	C	HGM 36	C
HGM 7	D	HGM 17	D	HGM 27	D	HGM 37	D
HGM 8	D	HGM 18	C	HGM 28	D	HGM 38	D
HGM 9	D	HGM 19	D	HGM 29	C		
HGM 10	D	HGM 20	D	HGM 30	D		

The proposed activities will impact on portions of the wetlands associated with the study area and their associated wetland drivers. Loss of wetland recharge from surface runoff, due to mining, is anticipated to occur, however the contribution of surface runoff is anticipated to be event driven (Important during a rainfall event), which therefore does not account for a significant contribution of water for the majority of the year although on an annualised scale surface runoff is considered an important driver of these wetlands.

The project will have an impact of varying severity on the wetland systems, depending on which alternatives are selected for final design. The hydropedological impacts have been identified and recommendations can be summarised as follows:

- Both proposed conveyor options and associated service roads traverse wetlands as well as areas regard essential for wetland recharge, the only difference being the extent in length of conveyor traversing the wetlands. Route A should be given consideration since the portion traversing the wetlands and wetland recharge soils is smaller than that of route B. Recommendations of the wetland assessment should however be strongly considered to ensure that the best option is selected.
- Although the expansion of the existing discard dump will impact a larger footprint of the wetland in comparison to the other options, impacts resulting from the existing discard dump are already directly or indirectly affecting wetlands (Valley bottom 2 and hillslope seep 19). Therefore, this should be strongly considered. Cogently developed and implemented mitigation measures are imperative since hillslope processes will likely mobilise contaminants (sulphates and various heavy metals) into the adjacent wetlands through subsurface flow paths:
    - Expansion into the wetland and interflow soils should be avoided as far as practically possible;
    - An appropriate barrier system should be engineered prior to expansion of the discard dump as measure to prevent seepage of contaminants into the groundwater regime and freshwater systems and must be appropriately maintained to mitigate impact during all phases of development; and
    - Furthermore, a dirty water trench (at least 1.5m) should be installed downgradient of the discard facility to capture seepage which might potentially pollute the wetlands.

From a hydropedological point of view, efforts should be focused on mitigating the impact on the wetland to be affected by the proposed developments, in line with the principles of sustainable development as stipulated in the National Environmental Management Act No 107 of 1998, as amended in 2017.

This document should be used as a guideline in the decision-making process to manage all watercourse associated with the mining operations by guiding the positioning, extent, design, management and rehabilitation of the mining areas.

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GLOSSARY OF TERMS

Alluvial soil:	A deposit of sand, mud, etc. formed by flowing water, or the sedimentary matter deposited thus within recent times, especially in the valleys of large rivers.
Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials e.g. gravel, sand, or silt, that contains and transmits groundwater
Base flow:	Long-term flow in a river that continues after storm flow has passed.
Catena	A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic condition, but having different characteristics due to variation in relief and drainage.
Catchment:	The area where water is collected by the natural landscape, where all rain and run-off water ultimately flows into a river, wetland, lake, and ocean or contributes to the groundwater system.
Chroma:	The relative purity of the spectral colour which decreases with increasing greyness.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants
Fluvial:	Resulting from water movement.
Gleying:	A soil process resulting from prolonged soil saturation which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.
Groundwater:	Subsurface water in the saturated zone below the water table.
Hydromorphic soil:	A soil that in its undrained condition is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).
Hydro period	Duration of saturation or inundation of a wetland system.
Hydrology:	The study of the occurrence, distribution and movement of water over, on and under the land surface.
Hydromorphy:	A process of gleying and mottling resulting from the intermittent or permanent presence of excess water in the soil profile.
Intermittent flow:	Flows only for short periods.
Mottles:	Soils with variegated colour patterns are described as being mottled, with the “background colour” referred to as the matrix and the spots or blotches of colour referred to as mottles.
Pedology	The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.
Perched water table:	The upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of groundwater
Runoff	Surface runoff is defined as the water that finds its way into a surface stream channel without infiltration into the soil and may include overland flow, interflow and base flow.
Swelling clay:	Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried.
Vadose zone	The unsaturated zone between the ground surface and the water table (groundwater level) within a soil profile
Watercourse:	In terms of the definition contained within the National Water Act, a watercourse means: • A river or spring; • A natural channel which water flows regularly or intermittently; • A wetland, dam or lake into which, or from which, water flows; and • Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse; • and a reference to a watercourse includes, where relevant, its bed and banks

ACRONYMS

°C	Degrees Celsius.
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
ET	Evapotranspiration
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
HGM	Hydrogeomorphic
m	Meter
MAP	Mean Annual Precipitation
MPRDA	Minerals and Petroleum Resources Development Act, Act 28 of 2002
NEMA	National Environmental Management Act
NWA	National Water Act
PSD	Particle Size Distribution
SACNASP	South African Council for Natural Scientific Professions
SAS	Scientific Aquatic Services
subWMA	Sub-Water Management Area
WMA	Water Management Areas
WULA	Water Use Licence Application

1 INTRODUCTION

1.1 Project Background

Scientific Aquatic Services (SAS) was appointed by Nsovo Environmental Consulting to conduct a hydropedological assessment as part of the Environmental Impact Assessment (EIA) process and Water Use License application for the proposed Exxaro Dorstfontein West Mine Expansion near Kriel, Mpumalanga Province

The study area is located approximately 19km northeast of Delmas, 19km west of Ogies, 50km south of Bronkhorstspruit (along the R42 and N12) along the N12, within Victor Khanye (Delmas) Local Municipality in the Nkangala Magisterial District, Mpumalanga (Figure 1 and 2 below).

The proposed activities entail the construction of a conveyor belt connecting DCM West and DCM East and associated service road, and an expansion of the discard dump facility which encroaches into the bordering wetlands as well as areas which are terrestrial in nature and comprise mostly of landuses associated to agriculture. Two (2) conveyor route options have been proposed. Thus, it is deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the mining activity areas to ensure that mine planning takes cognisance of the hydropedologically important areas.

A hydropedological survey and sampling activities were conducted in January 2019 to assess the hydropedological characteristics of the landscape and associated soils within the study area. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, in order to deduce the wetland recharge potential and identify the anticipated impacts on the hydropedological drivers of the wetlands due to the proposed mine.

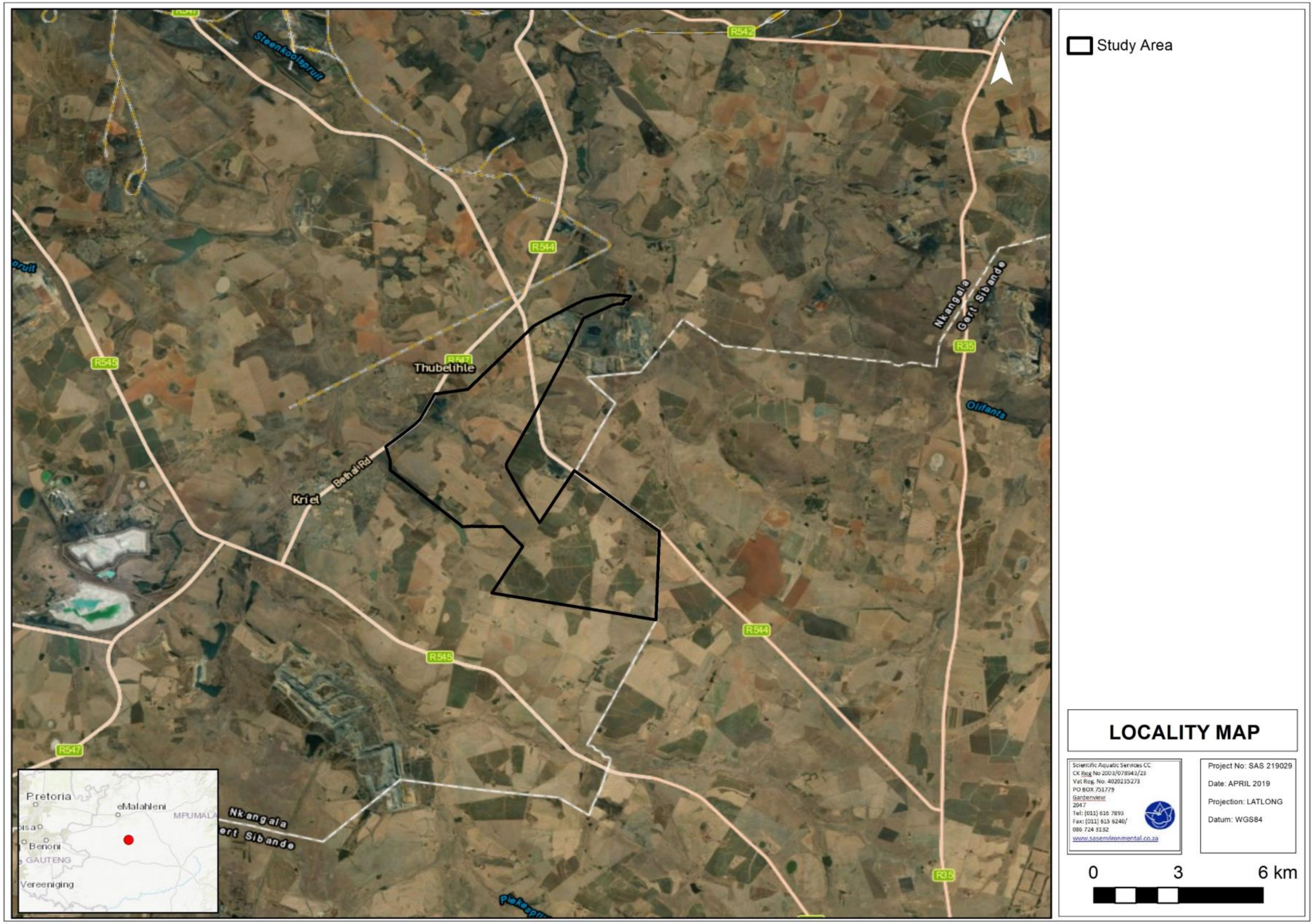

Figure 1: Locality map of the study area

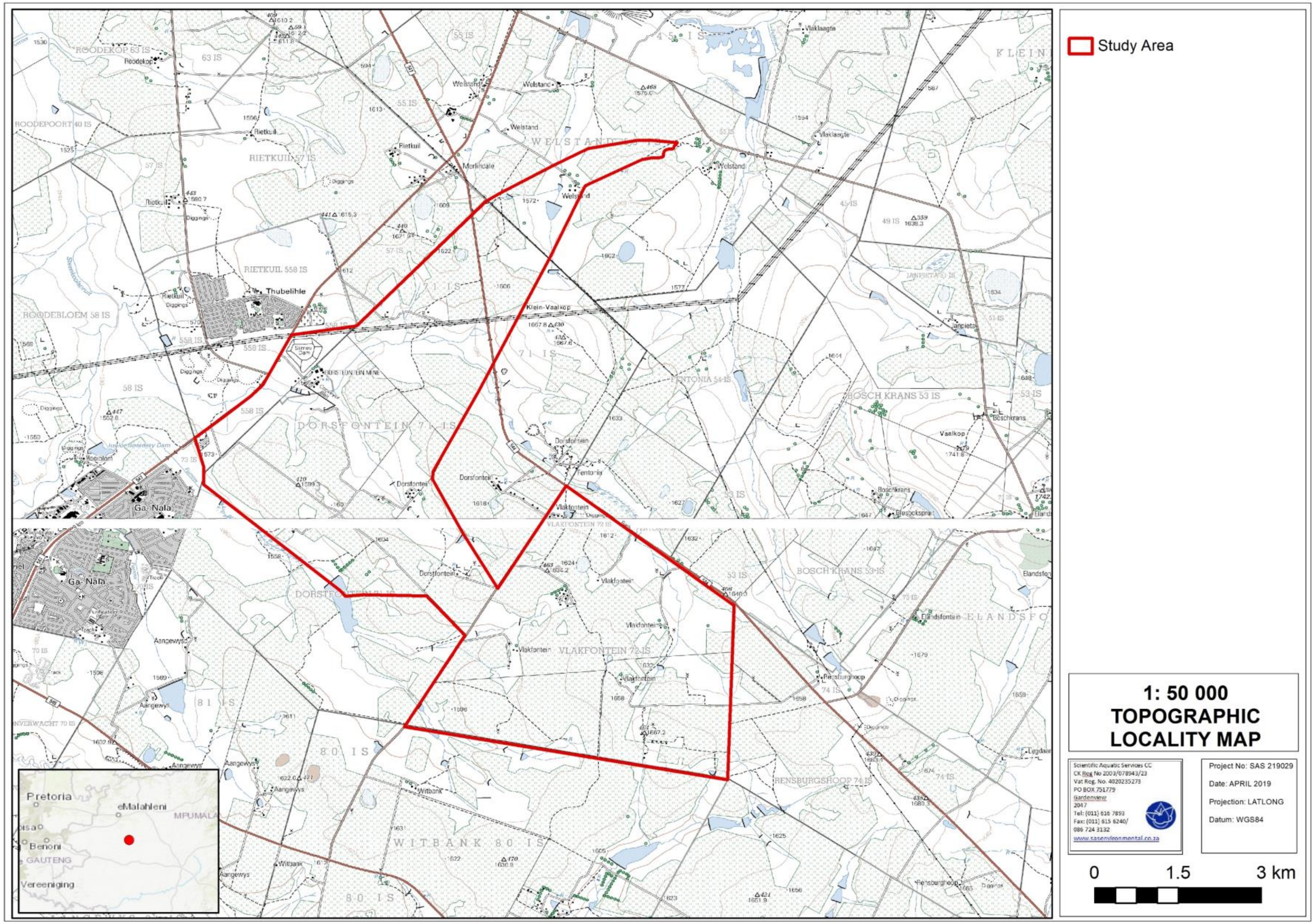

Figure 2: 1:50 000 topographic map of the study area

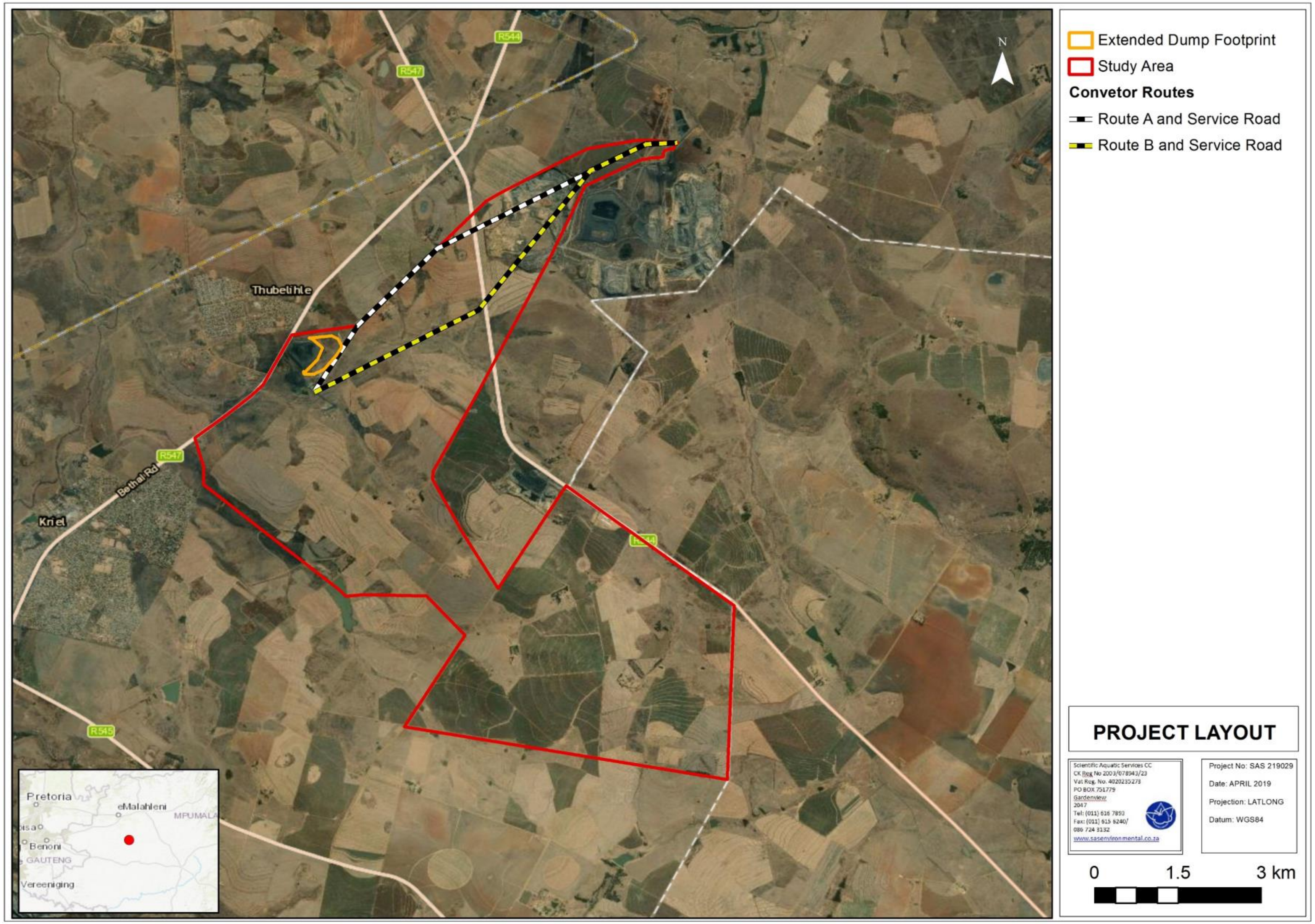

Figure 3: Map depicting the proposed mine layout

1.2 Objectives

The purpose of this assessment is to investigate the hydropedological properties of the soils in the vicinity of the wetland systems within the study area, to infer the potential recharge mechanisms and destination of the transferred water of the surrounding soils that may be affected during the life of the proposed mining activity. Further, to assess the impact of the proposed activities on the wetland systems in terms of the hydropedological drivers. Recommendations and mitigations were then considered and presented.

1.3 Assumptions and Limitations

Hydropedological science, and research is rapidly evolving and there are currently no standard methods to assess and/or model the recharge capacity of soils. As a result, the findings of this assessment are therefore a mix of qualitative and quantitative results and based on the specialist's training, opinion and experience with the hydrological properties of the identified soil types.

Hydropedological investigations are limited in the degree to which hydropedological losses can be quantified, with no standard method of approach to quantify the impact significance of various activities on the hydropedological drivers of wetland systems. For the assessment, a model was developed using basic hydrological principles in efforts to quantify the percentage loss of hydrological drivers due to the proposed activities. Although the model outcomes correlate with expected results and results obtained using other methods, the model used remains untested.

The wetlands presented in this document was sourced from a wetland assessment undertaken by WaterMakers in March 2019, as provided by the proponent. Verification of soil characteristics at selected points was undertaken during a field assessment by the hydropedological consultants. This approach was deemed sufficient to provide the relevant data to appropriately describe the wetland recharge mechanisms of the region.

Sampling by definition means that not all areas are assessed, and therefore some aspects of soil and hydropedological characteristics may have been overlooked in this assessment. However, it is the opinion of the professional study team that this assessment was carried out with sufficient sampling and in sufficient detail to enable the proponent, the Environmental Assessment Practitioner (EAP) and the regulating authorities to make an informed decision regarding the proposed activity.

The effects climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated reduction of water inputs and the resultant hydrological function of the remaining wetlands beyond the extent of the proposed mining project.

2 ASSESSMENT METHODOLOGY

A field assessment was undertaken in January 2019 to investigate the hydropedological properties of the soils in the vicinity of the investigated wetlands, to infer the recharge potential of the surrounding soils as best possible, based on their intrinsic pedological characteristics. Subsurface soil observations were made using a standard hand auger and investigation methods.

Field assessment data included description of physical soil properties including the following parameters, in order to characterise the various recharge mechanisms of the investigated wetlands:

- Diagnostic soil horizon sequence;
- Landscape position in relation to the investigated wetlands (recorded on GPS);
- Depth to saturation (water table), if encountered; and
- Collect selected samples for analysis at a SANAS accredited analytical laboratory;

Soil samples were provided to the laboratory for analysis of the following parameters:

- Particle size distribution (PSD) analyses to verify textural composition. The textural class was thereafter assigned according to the relative percentage fractions of clay, silt, and sand particles, as illustrated on the textural classification triangle in Figure 4. The permeability of the soils and their ability to transmit water through the landscape was thereafter estimated according to Table 1 and 2, commonly used in the Agricultural Industry.

Field assessment data was subsequently used to carry out the following assessments and investigation:

- Verify the spatial extent of the identified soil forms using a GIS software programme;
- Estimate the hydraulic conductivity according to soil texture according to the Food and Agriculture Organization (FAO, 1980) and DWS method (DWS, 2011);
- Identify the potential impacts of the proposed mining project on the unsaturated flow processes, and implications to the functionality of the wetland systems;
- Compile a brief report on the conceptual hydropedological regime of the assessed wetlands based on the soil types within the study area under current conditions. and

- Apply the DWS Risk Assessment Matrix to identify potential impacts that may affect the wetland systems as a result of the proposed development, and aim to quantify the significance; and
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the wetland hydropedological conditions.

Table 1: Average permeability for different soil textures in cm/hour Food and Agriculture Organization (FAO), 1980.

Soil Texture	Permeability (cm/hour)
Sand	5
Sandy loam	2.5
Loam	1.3
Clay loam	0.8
Silty clay	0.25
Clay	0.05

Table 2: Soil permeability classes for agriculture and conservation (Food and Agriculture Organization (FAO), 1980.

Soil permeability classes	Permeability rates*	
	cm/hour	cm/day
Very slow	Less than 0.13	Less than 3
Slow	0.13 - 0.3	3 - 12
Moderately slow	0.5 - 2.0	12 - 48
Moderate	2.0 - 6.3	48 - 151
Moderately rapid	6.3 - 12.7	151 - 305
Rapid	12.7 - 25	305 - 600
Very rapid	> 25	> 600

****Saturated samples under a constant water head of 1.27 cm***

Table 3 : DWS range of hydraulic conductivities in different soil types (DWS Groundwater Dictionary, 2011)

Soil Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Gravel	$3x10^{-2}$ – 3
Coarse Sand	$9x10^{-5}$ – $6x10^{-1}$
Medium Sand	$9x10^{-5}$ – $5x10^{-2}$
Fine Sand	$2x10^{-5}$ – $2x10^{-2}$
Loamy Sand	$4.1x10^{-3}$
Sandy Loam	$1.2x10^{-3}$
Loam	$2.9x10^{-4}$
Silt, Loess	$1x10^{-7}$ – $2x10^{-3}$
Silt Loam	$1.2x10^{-4}$
Till	$1x10^{-10}$ – $2x10^{-4}$
Clay	$1x10^{-9}$ – $4.7x10^{-7}$
Sandy Clay Loam	$3.6x10^{-4}$
Silty Clay Loam	$1.9x10^{-5}$
Clay Loam	$7.2x10^{-5}$
Sandy Clay	$3.3x10^{-5}$
Silty Clay	$5.6x10^{-6}$
Unweathered marine clay	$8x10^{-11}$ – $2x10^{-7}$

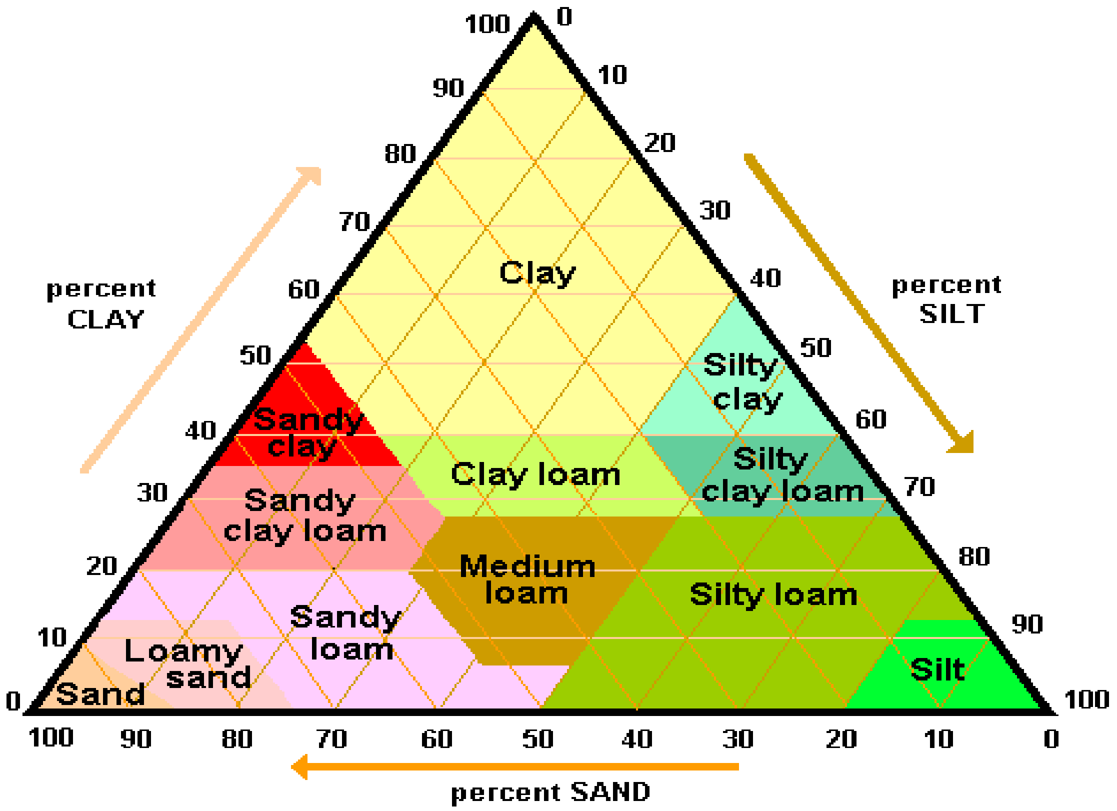

Figure 4: Soil texture classification chart (Food and Agriculture Organization (FAO), 1980.

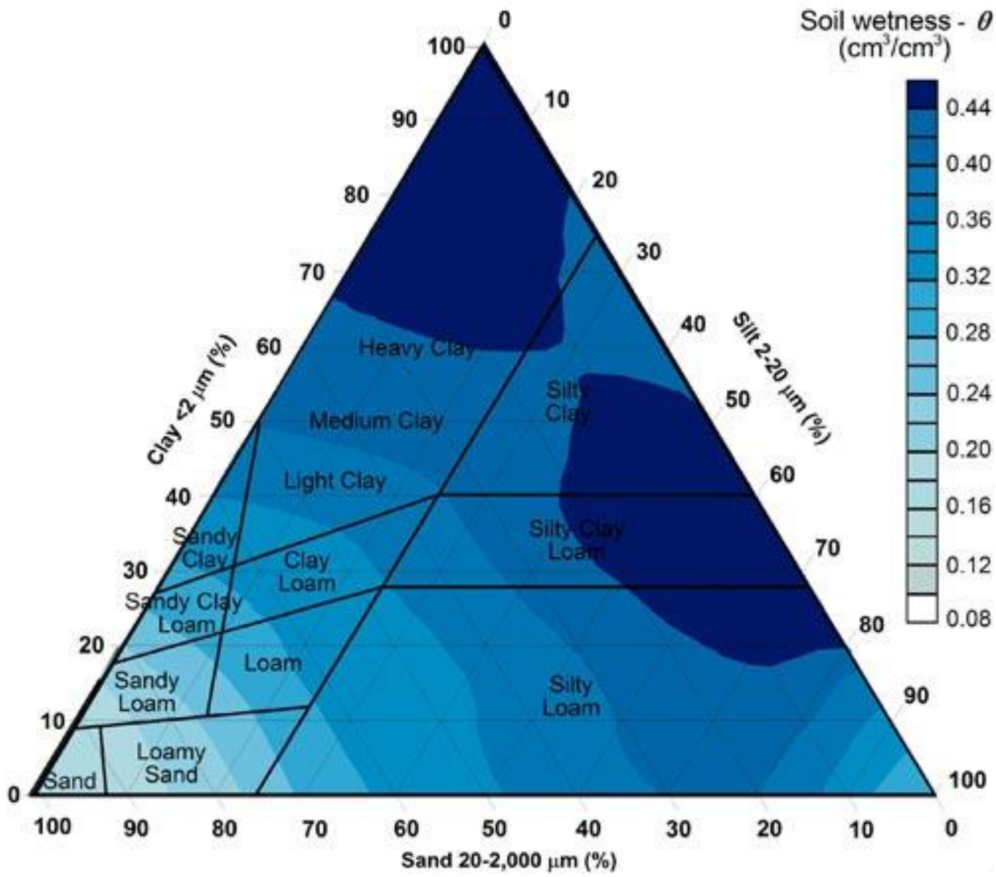

Figure 5: A diagram depicting soil wetness based on soil textural class

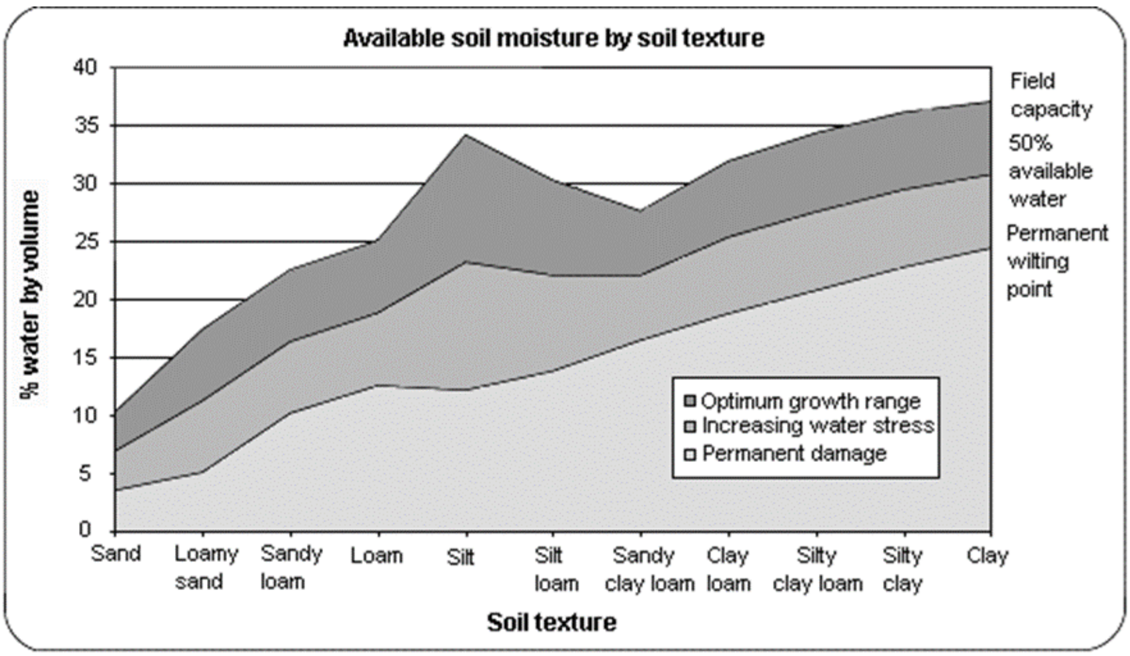

Figure 6: A diagram depicting the percentage volume of water in the soil by soil texture

2.1 Wetland Impact Calculation Approach

To accurately calculate the percentage loss for each wetland system associated with the study area, simple hydrological principles were applied. This approach considered various parameters such as:

- Rainfall;
- Hydropedological soil types
- Catchment area for each wetland system;
- Mean Annual Runoff; and
- Runoff coefficients (Mahmoud and Alazba, 2015) (Refer to Appendix B);
  - Slope percentage;
  - Soil texture;
  - Land use;

For each wetland system, a catchment area was delineated. In catchments which extended upgradient beyond the area where hydropedological data was gathered, the inflow into the study area was calculated using standard hydrological calculations of annual discharge. This value was used, where applicable, as an initial or catchment input volume to which the site specific hydropedological recharge values as well as other hydrological inputs were added. The contribution of the vadose zone or hydropedological input, taking into account its contribution to interflow, overland flow, expressed in percentage as well as estimated volumes of hydropedological recharge loss.

3 HYDROPEDOLOGICAL BEHAVIOUR OF SOIL TYPES

Hydropedological behavior of different soils can vary significantly, depending on the soil drainage patterns. The discussion below is based on the concept presented in Figure 7 and Table 4 below.

High chroma red soils are typically deep, well-drained, and vertical flow is the dominant hydrological pathway. These soils are referred to as recharge soils, as they are likely to recharge groundwater, or lower-lying positions in the regolith, via the fractured bedrock. Therefore, these systems may be important in terms of recharge over significant distances (several kilometers) and long periods (years to centuries). These soils are likely to contribute to surface freshwater systems three (3) stream order down in the landscape.

On the contrary, lighter coloured soils or leached soils are usually associated with lateral movement of water, which leaches soil mineral out of the soil through the process of eluviation.

Lateral flow occurs due to differences in the conductivity of soil horizons or due to the presence of an impermeable subsurface layer. These soils are termed interflow soils. Lateral flow occurs at the A/B horizon interface and/or bedrock interfaces due to the reduced permeability, which therefore prevents vertical movement. Fluctuating water tables in these areas leads to mottle formation (red, yellow and grey colours) at the level in the soil where the water level fluctuation occurs.

Grey colours in soils are mainly caused by prolonged saturation (hydroperiod), attributed to poor soil drainage due to high clay content or some other impediment. These soils drive wetlands on a more localised scale and the recharge path is generally completed over shorter periods (days to months depending on the transmissivity of the soils). Surface runoff occurs rapidly and leads to recharge of soils on a localised level after rainfall events. The Figure 7 depicts a conceptual diagram of the recharge mechanism of different soil types within the landscape and their influence on wetlands.

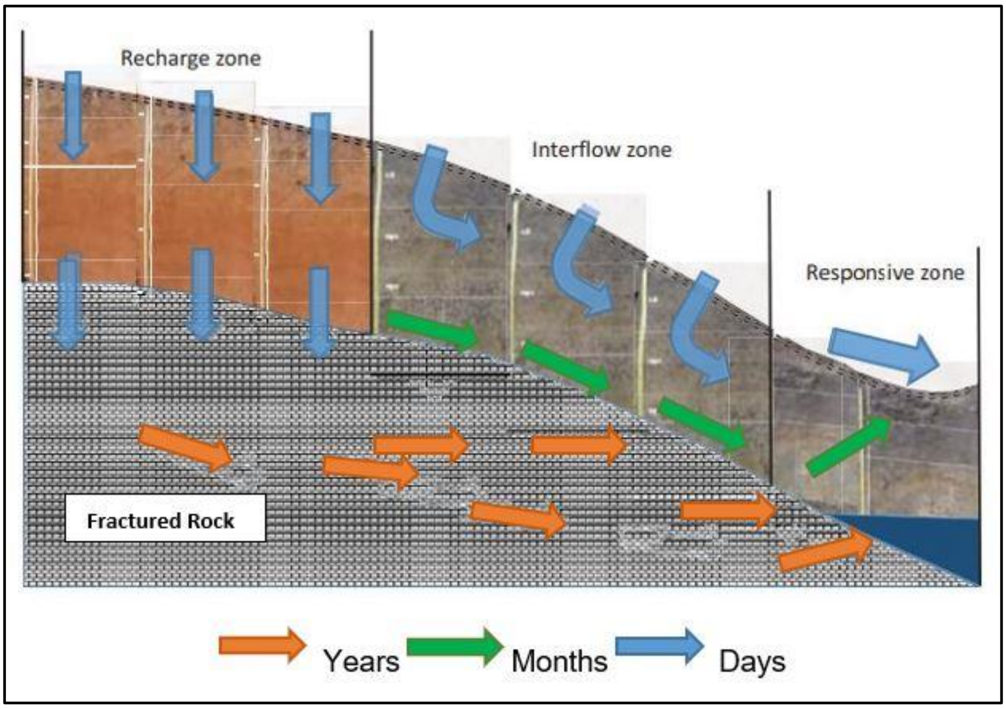

Figure 7: A typical conceptual presentation of hydrological flow paths on different hydropedological soil types- hillslope hydropedological behaviour.

3.1 Hydrological Soil Types

Table 4: Hydrological soil types of the studied hillslopes (Le Roux, *et al.,* 2015).

Hydrological Soil Types	Description	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to ground water regime.	
Interflow (A/B)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. Duration of drainable water depends on rate of evapotranspiration, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	
Interflow (Soil/Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build-up of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	
Responsive (Saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	

The flow paths from the crest of a slope to the valley bottom is assessed and classified. According to Le Roux, *et al.* (2015), the classification largely takes into account the flow drivers during a peak rainfall event and the associated flow paths of water through the soil. The hillslope classes are:

- Class 1 – Interflow (Soil/Bedrock Interface);
- Class 2 – Shallow responsive;
- Class 3 – Recharge to groundwater (Not connected);
- Class 4 – Recharge to wetland;
- Class 5 – Recharge to midslope; and
- Class 6 – Quick interflow.

4 ECOLOGICAL SIGNIFICANCE

According to the wetland assessment conducted by WaterMakers (2019), the study area comprises various wetlands systems, namely:

- Depression wetlands (pan);
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HGM 6	C	HGM 16	D	HGM 26	C	HGM 36	C
HGM 7	D	HGM 17	D	HGM 27	D	HGM 37	D
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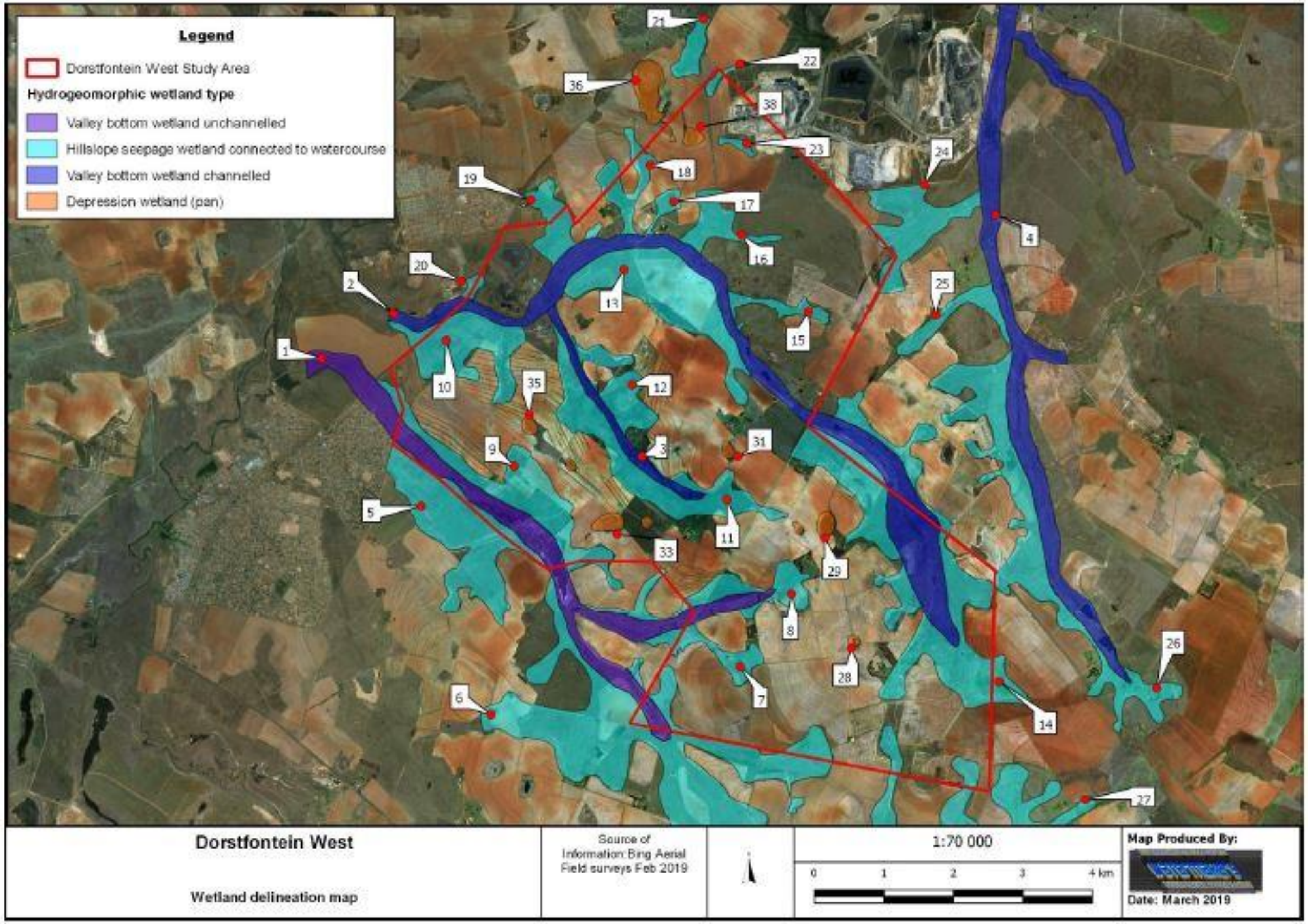

Figure 8: Wetlands within the study area, as delineated by WaterMakers (2019)

5 RESULTS AND DISCUSSION

5.1 Morphological and Hydraulic Properties of Wetland Soils within the Study Area:

The traversed catenas within the study area were dominated by a plinthic topo-sequence. Plinthic soils within the study area can be divided into soft and hard plinthic soil types, where in plinthic soils the Orthic A grades directly into a plinthic horizon, e.g., Westleigh and Dresden (Dr). Additionally, hard plinthic soils can also be moderately deep where the Orthic A horizon grades into a red or yellow-brown apedal horizon e.g. Glencoe (Gc). Whereas in soft plinthic soils the Orthic A can grade into an Albic Horizon, e.g., Longlands. Soft plinthic soils are generally wetter than the overlying horizon and have a high-water storage capacity attributed to their clayey and less permeable nature, which results in prolonged wetness after rainfall events. These soils, amongst others, discourage vertical movement of water and promote lateral flow, thus potentially important in terms of the wetland functioning. Soft plinthic soils largely occur in hillslope seeps as well as in pan/depression wetlands. Furthermore, the presence of a possible G horizon on Katspruit (Ka) and Kroonstad (Kd) soils indicates greater susceptibility to wetness, and these soils are typically saturated with water, at least seasonally. These soils are largely associated with valley bottom wetlands. Figure 9 depicts the locality of the soil within the study area as well as the delineated wetland features, respectively.

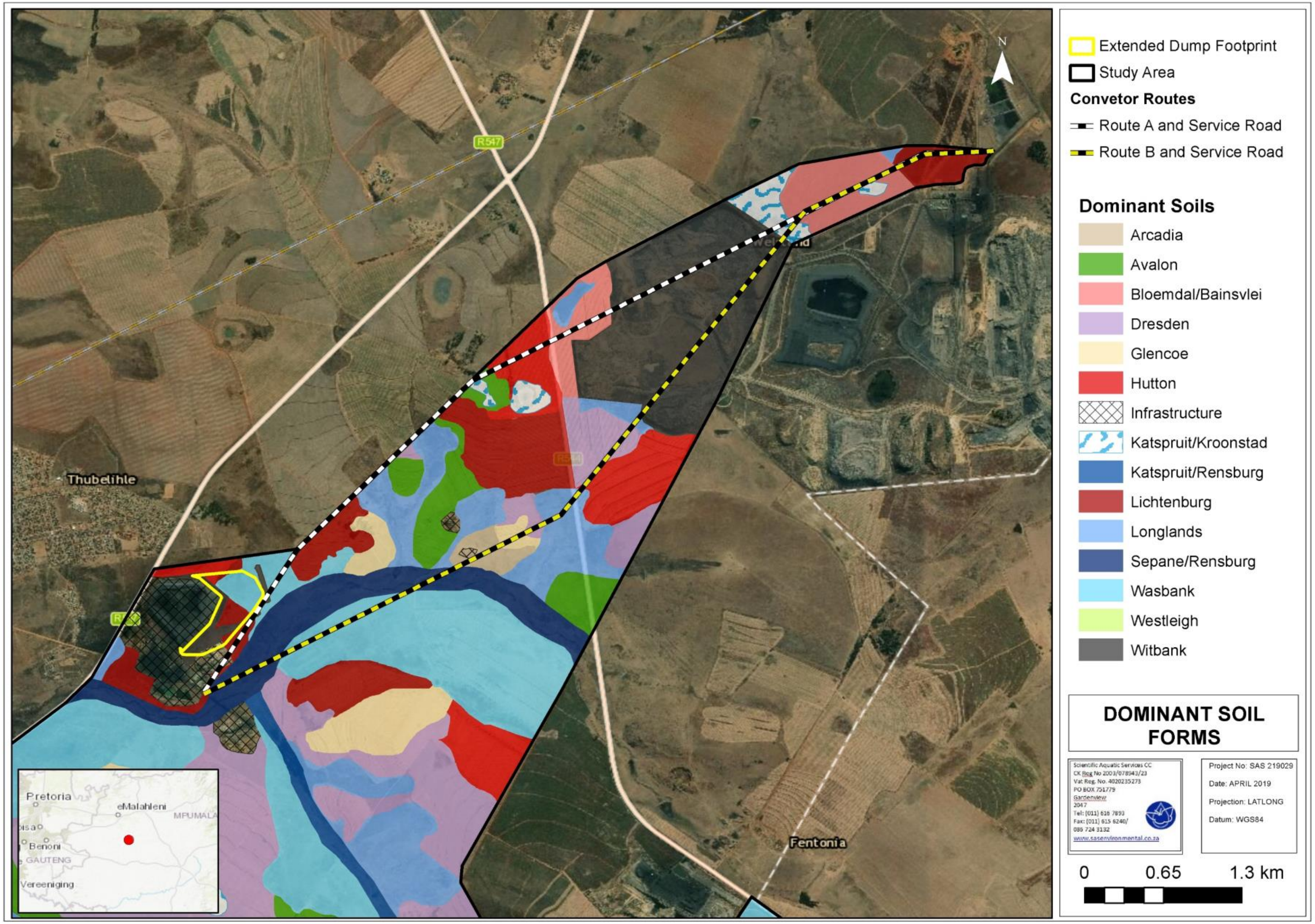

Figure 9: Map depicting the spatial distribution of soils within the study area

5.1.1 Responsive (Shallow)Soils

These soils are shallow, loamy sand of poor structure overlying a relatively impermeable hard plinthic horizon. Limited storage capacity results in the generation of overland flow after rain events. These soils lead to a rapid runoff response time during intense rainfall events attributed to their shallow nature, which inhibits infiltration. The slope position of the soils is typically the crest and scarp. It must be noted that these are not wetland soils, however, they are important for recharge of wetland during rainfall events by means of overland flow. Thus, only support wetlands during rainy seasons and particularly directly after rainfall events. The locality of these soils is depicted in Figure 10.

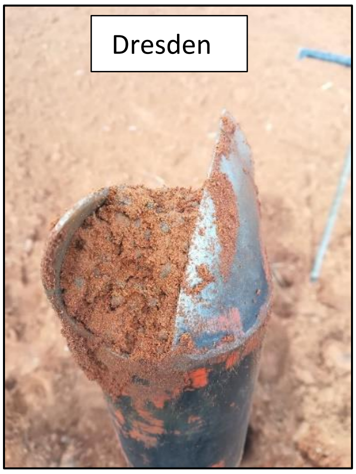

Figure 10: Photograph representing responsive shallow Dresden soils within the study area

5.1.2 Recharge Soils

Recharge soils are characterised by the absence of any morphological indication of saturation and are typically associated with deep freely drained soils. The dominant hydrological pathway for these soils is vertical through and out the profile into the underlying bedrock. These soils are termed recharge soils, as they are likely to recharge groundwater or lower-lying positions in the regolith via fractured bedrock. These soils can either be shallow on a fractured rock with a limited contribution to evapotranspiration or deep freely drained soils which can contribute significantly to evapotranspiration. Figure 11 below depicts Hutton (Hu) soil form, a typical recharge soil identified within the study area.

Figure 11: View of recharge soils with deep, well aerated and free draining characteristics

5.1.3 Interflow (A/B) Soils

Interflow soils discharge in a predominately lateral direction due to differences in the conductivity of horizons. The lateral flow occurs at the A/B horizon interface, due to the soft plinthic horizon restricting downward movement. The duration of the drainable water depends on the rate of ET (evapotranspiration), position in the hillslope. The interflow soils, as they contribute to the wetlands, are characterised by inherently poor internal drainage due to the slowly permeable underlying soft plinthite horizon. The lighter color of the Albic horizon further supports that lateral flow dominates (Le Roux, *et al.,* 2015). The interflow (A/B) soils within the study area comprised of Wasbank and Longlands soil forms, as depicted in Figure 12 below. The locality of these soils is illustrated in Figure 9 above.

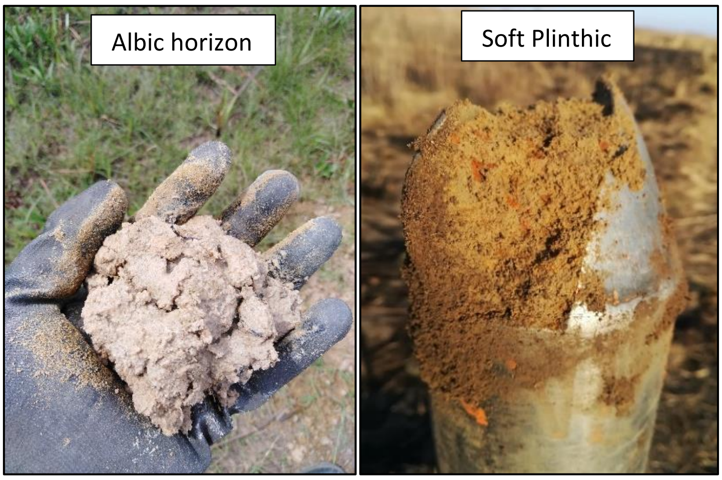

Figure 12: View of examples of the interflow soils in the A/B interface within the study area

5.1.4 Interflow (Soil/Bedrock) soils

These soils are characterised by hydromorphic properties particularly mottling (red, yellow, and grey colors) which signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction. The horizons are indicative that the underlying bedrock is slowly permeable and periodic saturation in the rainy season is likely, which may lead to lateral flow at the soil bedrock interface. The drainage may be restricted by a shallow impermeable rock layer (Le Roux, *et al.,* 2015). The interflow (Soil/Bedrock) soils within the study area comprised of Lichtenburg and Glencoe soil form, as depicted in Figure 13 below.

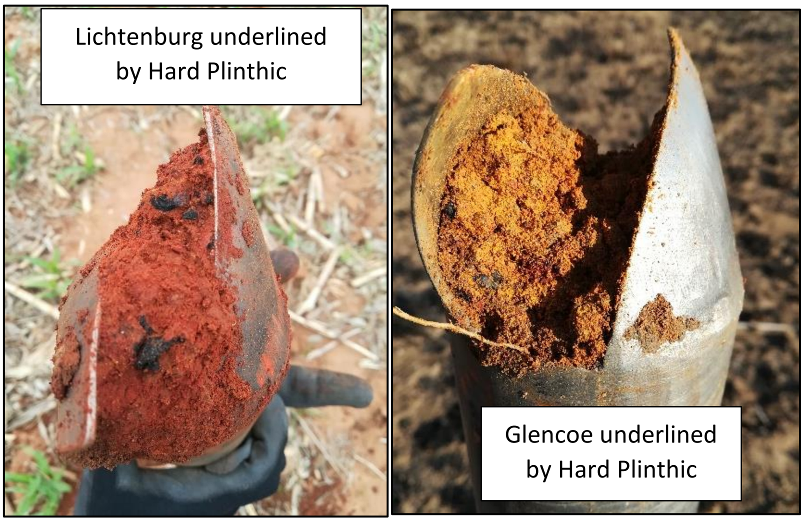

Figure 13: A depiction of an interflow soil in the soil/bedrock interface within the study area

5.2 Particle Size Distribution Analyses

Wetland hydrology is largely influenced by surrounding soil conditions as well as landscape position, amongst other factors. The ability of soils to recharge downstream wetlands and/or groundwater is mainly driven by the hydraulic conductivity, which is influenced by permeability according to particle size distribution (texture). The unsaturated flow plays potentially plays a pivotal role in the function of wetlands systems, particularly if the wetlands are largely recharged by interflow.

The particle size distribution analyses indicate that the texture of the surrounding soils is predominantly sandy loam and loamy sand, with few soils classified as sandy clay loam and clay, as presented in Table 6 below. This suggests that permeability of the representative sampled soils ranges between rapid and moderate, with a few soils comprising of a moderately slow permeability. Soils associated with valley bottom wetlands have a very low permeability due to the occurrence of high clay content soils. Permeability classes presented are according to the FAO (1980) and DWS (2011) permeability classification (refer to Table 2 and 3 above under Section 2). It must be noted that the DWS permeability classes were used, as these considered more applicable and representative of South African soil transmissivity.

Table 6: Textural classification of the dominant soil forms within the wetland catchment

Sampling point	Sampling Depth (cm)	Textural Class	Permeability Classes	FAO permeability (cm/day)	DWS permeability (cm/day)
1549	31 - 55	Sandy Loam	Moderate	59.616	103.68
1552	40 – 53				
1554	38 - 55				
1588	48 - 66				
1562	31 - 55	Loamy Sand	Rapid	354.24	354.24
1609	33 - 50	Clay	Slow	1.2096	8.6x10-5 - 0.041
1616	40 – 53	Sandy Clay Loam	Moderately Slow	31.104	31.104
1624	30 - 52				

5.3 Recharge of the Wetlands

Typically, there are four primary wetland recharge mechanisms, and these include precipitation (rainfall), surface flow (runoff), subsurface flow (interflow) through the vadose zone of the surrounding soils, and groundwater discharge.

The dominance of hard plinthic material as well as presence of Hillslope Seeps within the study area strongly suggests that the dominant flow path is lateral which implies that the proposed study area is important for recharging the freshwater systems within and in close proximity to the study area. In addition, the presence of isolated depressions wetlands (pans) in the surrounding areas may be indicative of the presence of a shallow perched aquifer). It is therefore highly likely that the wetland systems are largely driven by hillslope processes as well as shallow fractured aquifer/s, which have a direct interaction with the wetland systems.

Groundwater contribution to wetlands could not be verified as ground water studies were not available during this study. Groundwater studies should be consulted to verify the average water depth below ground surface, which will then give indications as to whether groundwater is a driver of the wetlands or not.

The contribution of overland flow and precipitation (rainfall) is considered significant during rainy seasons. Table 6 above present the hydrological grouping of soils occurring within the study area according to Van Toll and Le Roux (2016). The conceptual wetland recharge based on the water flow paths through the soil medium are presented in Table 7 below and Figure 14 depicts the locality of the wetland recharge soils.

Table 7: Hydrological grouping of soils occurring within the study area according to Van Toll and Le Roux (2016).

Recharge	Interflow		Responsive	Responsive
Deep	**A/B Horizon**	**Soil/Bedrock**	**Shallow**	
Hutton	Longlands	Lichtenburg	Dresden	Katspruit
	Wasbank	Glencoe	Mispah	Rensburg
	Kroonstad	Sepane		
	Westleigh	Bainsvlei		
		Tukulu		
		Avalon		

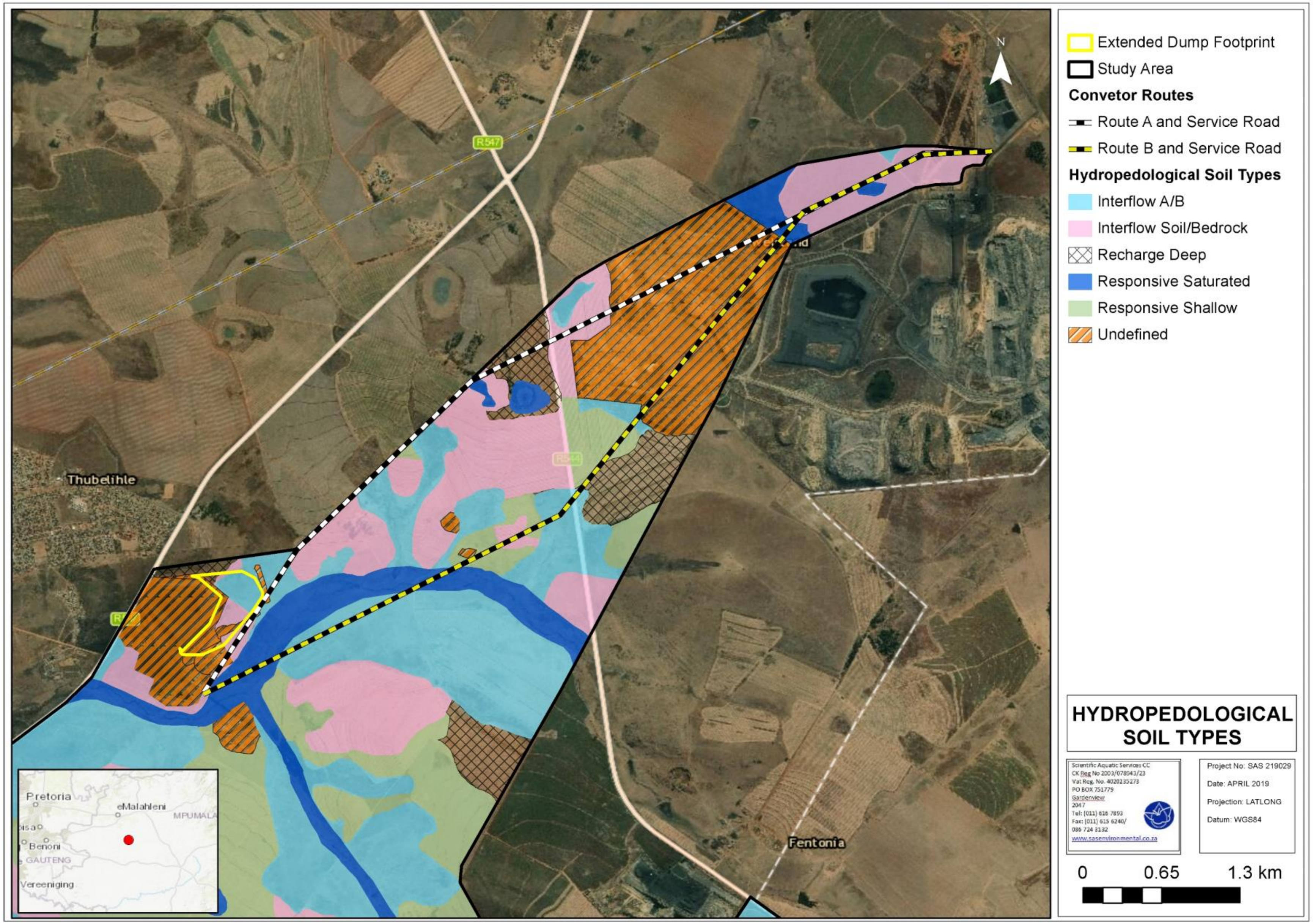

Figure 14: Map depicting hydrological soil types associated with the study area

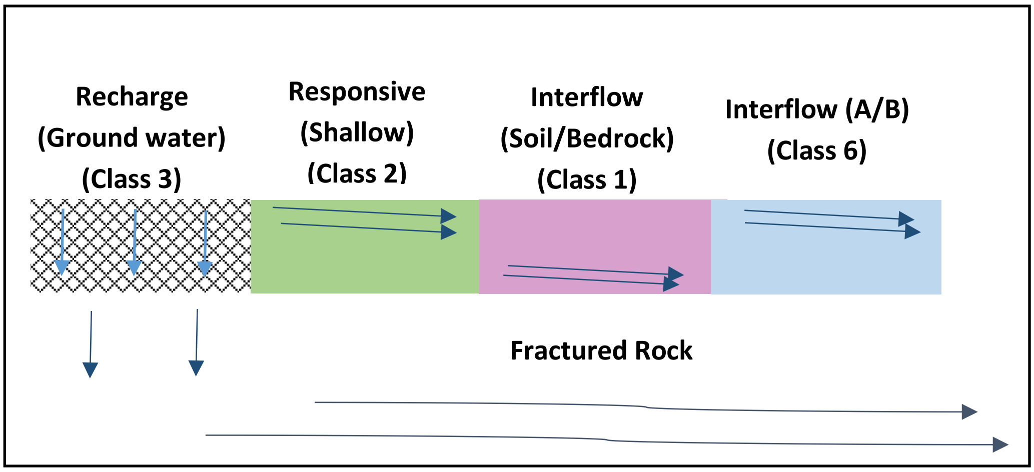

Figure 15: Hydrological responses in relation to the hydrological soil types within the study area A (Refer to Figure 14 above).

5.4 Hydro-pedological Implications

Table 8: Impact categories for describing the impact significance of the proposed mining activities on the wetlands and associated hydropedological drivers

Severity	SSI Reduction	Change Class	Description
No Impact	0 – 2.5 %	No change	Hydropedological process are predicted to be unmodified and the functionality of the wetland will remain unchanged
Low	2.5 – 5 %	No Significant change	Small effect on the hydropedological process are predicted, however the functionality of the wetland remains unchanged and no change in resource class is expected.
Low to Moderate	5 – 10 %	Limited change with a change in PES category possible	A slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but is change to the PES, EIS or wetland functionality and ecoservice provision is limited with no more than one PES class predicted.
Moderate	10 – 15 %	Significant change with a change in PES Category definite and possibly a change of more than one category	A moderate change in the hydropedological processes is predicted to occur, The change in PES may exceed one category but no change in EIS takes place. No loss of important ecoservices is predicted to occur
High	15 – 22.5 %	Very significant change with a change in PES of more than two categories	Modifications have reached a very significant level and the hydropedological processes are predicted to be largely modified with a large change in the PES, EIS of the wetland feature as well as a significant loss in ecoservice provision.
Very High	22.5 -60%	Serious to Critical change with a change in PES of more than three categories or a permanent complete loss of wetland resource	Modifications have reached a serious level and the hydropedological processes have been seriously modified with an almost complete loss of wetland integrity, functionality and service provision.

5.4.1 Conveyor Routes and Associated Service Roads

Both proposed conveyor options and associated service roads traverse wetlands as well as areas regarded essential for wetland recharge, the only difference being the extent of conveyor traversing the wetlands. Conveyor Route A and associated service road traverse two (2) hillslope seeps well as interflow soils important for wetland recharge, whilst Conveyor Route B and associated service road traverse two hillslope seeps and a valley bottom wetland twice, and this is regarded to have the highest impact from the hydropedological point of view since valley bottom soils are highly susceptible to compaction than soils at the crest and mid slopes. Compaction may potentially affect the subsurface flow, particularly at the A/B soil interface and subsequently affecting hydropedological driver component. While both options pose an impact on the hydropedological drivers of the wetlands, route A and associated service road will have the least impact, however recommendations of the wetland assessment should also be taken into consideration to ensure that the option with the least impact both on wetlands and hydropedological drivers is selected, in line with the principles of sustainable development. Quantification of hydropedological losses for conveyors and associated service roads was not deemed necessary, however, these were assessed as part of the risk assessment.

5.4.2 Expanded Dump Footprint

The portion of the proposed expansion footprint will occur within a hillslope seep wetland, and interflow soils regarded important for recharging the wetlands. A trench line was evident within the hillslope seep overlain by the expanded dump footprint, which captures seepage from the existing discard dump. Although expansion footprint will impact a larger wetland in comparison to the other options which were dismissed during the scoping phase, impacts resulting from the existing discard dump are already directly or indirectly affecting wetlands (Valley bottom 2 and hillslope seep 19).

Table 9: Calculated percentage loss of wetland recharge on both local and catchment scale for expanded discard dump

HGM	Local Scale		Catchment Scale		Change Class
	% Loss on a local scale	Wetland Impact Category	% Loss on a catchment scale	Wetland Impact Category	
19	5.44	Low to Moderate	5.44	Low to Moderate	A slight change in hydropedological processes is predicted and a small change in the in the wetland may have taken place but change to the PES, EIS or wetland

					functionality and ecoservice provision is limited with no more than one PES class predicted.
Average	**5.44**		**5.44**		

Based on the outcomes of the hydropedological loss quantification exercise, the loss is anticipated to be low to moderate. This is largely due to the direct impact since the proposed discard expansion will encroach on the wetland.

5.4.3 Buffer Determination Using Hydropedological Principles

Following the quantification of the anticipated hydropedological loss due to the proposed development, it was determined that there would be an impact on the adjacent wetlands, which will be indirectly impacted by mining and related activities. The proponent must engage with the DHSWS as the custodians of South Africa's water resources, to ensure that appropriate management measures are afforded in line with the principles of Integrated Environmental Management and sustainable development. Attention should also be paid to the mitigation measures presented in both this study and the freshwater impact assessment to reduce the impact on the receiving environment.

6 Requirements of the Government Notice 704 in Government Gazette 20119

The GN 704 regulations were consulted during this study, as a minimum requirement stipulated under the regulation for any person in control of the mine to carry some of the activities. This Regulation was put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining.

Under the definitions section on Regulation GN 704:
"activity", means -

(a) any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants, and
(b) the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not,

(i) in which any substance is stockpiled, stored, accumulated or transported for use in such process; or

(ii) out of which process any residue is derived, stored, stockpiled, accumulated, dumped, disposed of or transported;

"clean water system", includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted water;

"dirty water system", includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste;

Under the “Capacity requirements of clean and dirty water systems” section, it is stated that:
Every person in control of a mine or activity must-

(a) confine any unpolluted water to a clean water system, away from any dirty area;

(b) design, construct, maintain and operate any clean water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years;

(c) collect the water arising within any dirty area, including water seeping from mining operations. outcrops or any other activity, into a dirty water system;

(d) design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years; and

(e) design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 meters above full supply level, unless otherwise specified in terms of Chapter 12 of the Act.

(f) design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years.

Based on the above extract from Regulation GN 704, a stormwater management plan should be implemented. Refer to the wetland report (SAS, 2018).

7 RISK ASSESSMENT

This section presents the significance of potential impacts on the affected wetlands within the study area and their associated hydropedological drivers. In addition, it indicates the required mitigatory measures required to minimise the perceived impacts of the proposed activities and presents an assessment of the significance of the impacts taking into consideration the available mitigatory measures and assuming that they are fully implemented.

The risk assessment was based on the information as provided by the proponent, which includes the following:

- The proposed conveyor routes and service roads traverse wetlands and their associated hydropedological drivers; and
- Expansion of discard dump footprint encroaches onto the wetland;

Table 10: DWS Risk Assessment and mitigation measures applicable to the affected wetlands within the study area.

Phases	Activity	Aspect	Impact	Consequence	Frequency of activity	Frequency of impact	Likelihood	Significance	Risk Rating	Control Measures
Construction	Site preparation prior to commencement mining, including placement of contractor laydown areas and storage facilities	*Vehicular movement and access to the site; *Removal and associated disturbances to wetland recharge soils and the wetlands; and *Possible unplanned and uncontrolled movement of construction equipment through the wetland recharge soils.	*Alteration to hydropedological flow paths pat, leading to degradation of wetland and associated wetland recharge soils; *Impacts to wetlands and associated wetland recharge soils destroyed by proposed mining activities: *Exposure of soils, leading to increased runoff from cleared areas and erosion of the wetlands, and thus increased the potential for sedimentation of the wetlands; *Impacts on the hydropedological processes supporting the wetlands; and *Soil compaction.	9	1	2	10	90	M	*All development footprint areas to remain as small as possible and vegetation clearing to be limited to what is absolutely essential; *Retain as much indigenous vegetation as possible; *Exposed soils to be protected by means of a suitable covering; *Existing roads should be used as far as practically to gain access to site, and crossing the wetlands in areas where no existing crossing is apparent should be unnecessary, but if it is essential crossings should be made at right angles;
	Construction of the conveyor routes **Conveyor Route A** - Traverses HGM 19 and 18, and interflow soils regarded important for wetland recharge. This option is located in the upgradient areas of the catchment of the wetlands;	*Excavation activities as part of conveyor pillar installation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate.	8	1	2	10	80	M	*If possible, vegetation clearing should be done in a phased manner to limit bare/exposed soils which are prone to erosion. *Exposed soils to be protected by suitable covering;

	Construction of the conveyor routes **Conveyor Rout B** - This route is located in the valley bottom areas, and traverses HGM 2, 13, 16 and 23	*Excavation activities as part of conveyor pillar installation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate.	**10**	**1**	**2**	**10**	**100**	**M**	*If possible, vegetation clearing should be done in a phased manner to limit bare/exposed soils which are prone to erosion. *Exposed soils to be protected by suitable covering;
	Construction of the conveyor service roads **Service Road Route A** - Traverses HGM 19 and 18, and interflow soils regarded important for wetland recharge. This option is located in the upgradient areas of the catchment of the wetlands	*Excavation activities as part of ground preparation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate.	**11**	**1**	**2**	**10**	**110**	**M**	*If possible, vegetation clearing should be done in a phased manner to limit bare/exposed soils which are prone to erosion. *Exposed soils to be protected by suitable covering;
	Construction of the conveyor service roads **Service Road Rout B** - This route is located in the valley bottom areas, and traverses HGM 2, 13, 16 and 23	*Excavation activities as part of ground preparation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate.	**13**	**1**	**2**	**10**	**130**	**M**	*If possible, vegetation clearing should be done in a phased manner to limit bare/exposed soils which are prone to erosion. *Exposed soils to be protected by suitable covering;
	Construction of the discard dumps **Expanded Dump Footprint** - Encroaches onto HGM 19, and interflow soils regarded important for wetland recharge;	*Excavation activities as part of site preparation	*Removal of wetland recharge soils and *Compaction of soil, leading to increased runoff rate.	**9**	**4**	**2**	**13**	**117**	**M**	*The discard dump must be lined with impermeable clay material to limit mobility of contaminants into the wetlands and groundwater regime;

Operational Phase	Operation of the Conveyor route	*Pillars installed within wetland recharge soils	*Interception of interflow important for sustaining the wetlands	**7**	**1**	**3**	**6**	**42**	**L**	*Avoid installation of conveyor within wetlands and interflow soils as far as practically possible; *Should it not be feasible; Route A should strongly considered.
	Operation of Discard dump	*Expansion of Discard dump footprint largely located within hillslope seep and associated wetland recharge soils; *Dumping of discard on interflow flow soils;	*Partial loss of the wetlands located within the proposed discard dump footprint as well associated wetland recharge soils	**9**	**1**	**2**	**10**	**90**	**M**	*The discard dump must be lined with impermeable clay material to limit mobility of contaminants into the wetlands and groundwater regime;
Closure and Rehabilitation	Rehabilitation of mining footprint areas (with specific focus on mining areas).	Demolition of infrastructure	Compacted soils, latent impacts of vegetation losses, causing: *Increased runoff volumes and formation of preferential surface flow paths as a result of compacted soils, leading to alteration of hydropedological flow paths, increased sedimentation and erosion.	**7**	**1**	**3**	**6**	**42**	**L**	*Concurrent rehabilitation should strongly be considered to ensure that the duration that any pit or extent thereof is left unrehabilitated is minimised; *Restrict the amount of mechanical handling of soils, as each excise increase the compaction level; *A very well designed, managed and executed topsoil (separate from soft overburden) management program is highly recommended where separate stripping, stockpiling and replacing of soil horizons [A (0-30 cm) and B (30-60 cm)] in the original natural sequence to combat hardsetting and compaction is ensured; *Separate stockpiling of different soils such that soils which are regarded as important for wetland recharge (i.e. Longlands, Wasbank and Glencoe) are separated from ground water recharge soils (i.e. Hutton); *Stockpile height should be restricted to that which can deposited without additional traversing by machinery. A Maximum height of 2-3 m is therefore

											proposed, and the stockpile should be treated with temporary soil stabilisation methods.

CONCLUSIONS AND RECOMMENDATIONS

Scientific Aquatic Services (SAS) was appointed by Nsovo Environmental Consulting to conduct a hydropedological assessment as part of the Environmental Impact Assessment (EIA) process and Water Use License application for the proposed Exxaro Dorstfontein West Mine Expansion near Kriel, Mpumalanga Province.

The proposed activities entail construction of a conveyor belt connecting the west and east mine, and an expansion of the discard dump facility which encroaches into the bordering wetlands as well as areas which are terrestrial in nature and comprise mostly of landuses associated to agriculture. Two (2) conveyor route options and service roads have been proposed. Thus, it is deemed necessary to investigate the recharge mechanism of the wetland systems within and in close proximity to the mining activity areas to ensure that mine planning takes cognizance of the hydropedologically important areas.

According to the wetland assessment conducted by WaterMakers (2019), the study area comprises various wetlands systems, namely:

- Depression wetlands (pan);
- Hillslope Seeps;
- Channeled Valley Bottom wetlands;
- Unchanneled Valley Bottom wetlands; and

According to WaterMakers (2019), the wetland systems have been impacted to some degree, owing to grazing, mining as well as current and historical agricultural activities within the catchment, vegetation clearing, and road infrastructure. Table 5 presents summary results of the Present Ecological State (PES) the wetland systems associated with the proposed development.

Table: Summary results of the Present Ecological State (PES) of the wetlands

HGM Unit	PES Category	HGM Unit	PES Category	HGM Unit	PES Category	HGM Unit	PES Category
HGM 1	**C**	HGM 11	D	HGM 21	D	HGM 31	D
HGM 2	**C**	HGM 12	D	HGM 22	F	HGM 32	D
HGM 3	**C**	HGM 13	D	HGM 23	F	HGM 33	D
HGM 4	D	HGM 14	C	HGM 24	C	HGM 34	D
HGM 5	D	HGM 15	D	HGM 25	C	HGM 35	D
HGM 6	C	HGM 16	D	HGM 26	C	HGM 36	C
HGM 7	D	HGM 17	D	HGM 27	D	HGM 37	D
HGM 8	D	HGM 18	C	HGM 28	D	HGM 38	D

HGM 9	D	HGM 19	D	HGM 29	C		
HGM 10	D	HGM 20	D	HGM 30	D		

The proposed activities will impact on portions of the wetlands associated with the study area and their associated wetland drivers. Loss of wetland recharge from surface runoff, due to mining, is anticipated to occur, however the contribution of surface runoff is anticipated to be event driven (Important during a rainfall event), which therefore does not account for a significant contribution of water for the majority of the year although on an annualised scale surface runoff is considered an important driver of these wetlands.

The project will have an impact of varying severity on the wetland systems, depending on which alternatives are selected for final design. The hydropedological impacts have been identified and recommendations can be summarised as follows:

- Both proposed conveyor options and associated service roads traverse wetlands as well as areas regard essential for wetland recharge, the only difference being the extent in length of conveyor traversing the wetlands. Route A should be given consideration since the portion traversing the wetlands and wetland recharge soils is smaller than that of route B. Recommendations of the wetland assessment should however be strongly considered to ensure that the best option is selected.
- Although the expansion of the existing discard dump will impact a larger footprint of the wetland in comparison to the other options, impacts resulting from the existing discard dump are already directly or indirectly affecting wetlands (Valley bottom 2 and hillslope seep 19). Therefore, this should be strongly considered. Cogently developed and implemented mitigation measures are imperative since hillslope processes will likely mobilise contaminants (sulphates and various heavy metals) into the adjacent wetlands through subsurface flow paths:
    - Expansion into the wetland and interflow soils should be avoided (If feasible);
    - An appropriate barrier system should be engineered prior to expansion of the discard dump as measure to prevent seepage of contaminants into the groundwater regime and freshwater systems and must be appropriately maintained to mitigate impact during all phases of development; and
    - Furthermore, a dirty water trench should be installed downgradient of the discard facility to capture seepage which might potentially pollute the wetlands.

From a hydropedological point of view, efforts should be focused on mitigating the impact on the wetland to be affected by the proposed developments, in line with the principles of sustainable development as stipulated in the National Environmental Management Act No 107 of 1998, as amended in 2017.

This document should be used as a guideline in the decision-making process to manage all watercourse associated with the mining operations by guiding the positioning, extent, design, management and rehabilitation of the mining areas.

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APPENDIX A: PARTICLE SIZE ANALYSIS RESULTS

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CERTIFICATE OF ANALYSES
PARTICLE SIZE DISTRIBUTION [s]

Date received: 2019-01-28
Date completed: 2019-02-12
Project number: 244
Report number: 80412
Order number: Dorsfontein

Client name: Scientific Aquatic Services
Contact person: Braveman Mzila
Address: 347 Highland Road, Kensington, 2094
Email: brave@sasenvgroup.co.za
Telephone: 011 616 7893
Fax: 086 724 3132
Cell: 078 152 6993

	Sample Identification
	1609
Sample Number	**53347**
Material Description	Sandy Clay
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	99
0.425 mm	96
0.075 mm	73
Hydrometer analysis (% Passing)	
54 µm	59
32 µm	55
13 µm	49
6 µm	45
2 µm	40
% Clay	45
% Silt	14
% Sand	40
% Gravel	1

Please note:
[s] = Subcontracted

	Sample Identification
	1624
Sample Number	**53348**
Material Description	Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	100
2.00 mm	99
0.425 mm	89
0.075 mm	42
Hydrometer analysis (% Passing)	
54 µm	31
32 µm	26
13 µm	24
6 µm	23
2 µm	19
% Clay	23
% Silt	8
% Sand	68
% Gravel	1

	Sample Identification
	1552
Sample Number	**53349**
Material Description	Gravelly Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	84
2.00 mm	67
0.425 mm	62
0.075 mm	29
Hydrometer analysis (% Passing)	
56 µm	22
33 µm	19

13 µm	17
6 µm	14
2 µm	12
% Clay	14
% Silt	8
% Sand	45
% Gravel	33

	Sample Identification
	1588
Sample Number	**53350**
Material Description	Gravelly Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	84
2.00 mm	71
0.425 mm	64
0.075 mm	29
Hydrometer analysis (% Passing)	
52 µm	21
31 µm	19
12 µm	15
5 µm	14
2 µm	12
% Clay	14
% Silt	7
% Sand	50
% Gravel	29

	Sample Identification
	1562
Sample Number	**53351**
Material Description	Silty Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100

20.0 mm	100
14.0 mm	100
5.0 mm	99
2.00 mm	99
0.425 mm	89
0.075 mm	23
Hydrometer analysis (% Passing)	
59 µm	12
34 µm	7
14 µm	5
6 µm	3
2 µm	1
% Clay	3
% Silt	9
% Sand	87
% Gravel	1

	Sample Identification
	1549
Sample Number	**53352**
Material Description	Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	97
2.00 mm	92
0.425 mm	84
0.075 mm	27
Hydrometer analysis (% Passing)	
59 µm	21
34 µm	16
14 µm	13
6 µm	11
2 µm	10
% Clay	11
% Silt	10
% Sand	71
% Gravel	8

	Sample Identification
	1554
Sample Number	**53354**
Material Description	Gravelly Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	96
5.0 mm	84
2.00 mm	82
0.425 mm	76
0.075 mm	29
Hydrometer analysis (% Passing)	
59 µm	19
34 µm	15
14 µm	13
6 µm	12
2 µm	10
% Clay	12
% Silt	7
% Sand	63
% Gravel	18

	Sample Identification
	1616
Sample Number	**53355**
Material Description	Clayey Sand
Screen analysis (% Passing)	
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	100
14.0 mm	100
5.0 mm	97
2.00 mm	95
0.425 mm	91
0.075 mm	47
Hydrometer analysis (% Passing)	
59 µm	38
34 µm	32

14 µm	29
6 µm	25
2 µm	18
% Clay	25
% Silt	13
% Sand	57
% Gravel	5

APPENDIX D: DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden MSc (Environmental Management) (University of Johannesburg)

Braveman Mzila BSc (Hons) Hydrology University of KwaZulu-Natal

1. (a). (ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

Company of Specialist:	Scientific Aquatic Services		
Name / Contact person:	Stephen van Staden		
Postal address:	29 Arterial Road West, Oriel, Bedfordview		
Postal code:	2007	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	011 615 6240/ 086 724 3132
E-mail:	stephen@sasenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum		

1. (b) a declaration that the specialist is independent in a form as may be specified by the competent authority

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

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Signature of the Specialist

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION
CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Managing member, Ecologist with focus on Freshwater Ecology
Date of Birth	13 July 1979
Nationality	South African
Languages	English, Afrikaans
Joined SAS	2003 (year of establishment)
Other Business	Trustee of the Serenity Property Trust and emerald Management Trust

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP);
Accredited River Health practitioner by the South African River Health Program (RHP);
Member of the South African Soil Surveyors Association (SASSO);
Member of the Gauteng Wetland Forum;
Member of International Association of Impact Assessors (IAIA) South Africa;
Member pf the Land Rehabilitation Society of South Africa (LaRSSA)

EDUCATION

Qualifications

MSc (Environmental Management) (University of Johannesburg)	2003
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2001
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	2000
Tools for wetland Assessment short course Rhodes University	2016

COUNTRIES OF WORK EXPERIENCE

South Africa – All Provinces
Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe Zambia
Eastern Africa – Tanzania Mauritius
West Africa – Ghana, Liberia, Angola, Guinea Bissau, Nigeria, Sierra Leone
Central Africa – Democratic Republic of the Congo

PROJECT EXPERIENCE (Over 2500 projects executed with varying degrees of involvement)

1 Mining Coal, Chrome, PGM's, Mineral Sands, Gold, Phosphate, river sand, clay, fluorspar
2 Linear developments
3 Energy Transmission, telecommunication, pipelines, roads
4 Minerals beneficiation
5 Renewable energy (wind and solar)
6 Commercial development
7 Residential development
8 Agriculture
9 Industrial/chemical

REFERENCES

- Terry Calmeyer (Former Chairperson of IAIA SA)
  Director: ILISO Consulting Environmental Management (Pty) Ltd

Tel: +27 (0) 11 465 2163
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- Alex Pheiffer
  African Environmental Management Operations Manager
  SLR Consulting
  Tel: +27 11 467 0945
  Email: apheiffer@slrconsulting.com

- Marietjie Eksteen
  Managing Director: Jacana Environmental
  Tel: 015 291 4015

Yours faithfully

STEPHEN VAN STADEN

SCIENTIFIC AQUATIC SERVICES (SAS) – SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF BRAVEMAN MZILA

PERSONAL DETAILS

Position in Company	Wetland Ecologist and Soil Scientist
Date of Birth	03 January 1991
Nationality	South African
Languages	IsiZulu, English
Joined SAS	2017

EDUCATION

Qualifications

BSc (Hons) Environmental Hydrology (University of KwaZulu-Natal)	2013
BSc Hydrology and Soil Science (University of KwaZulu-Natal))	2012

COUNTRIES OF WORK EXPERIENCE

South Africa – Gauteng, KwaZulu-Natal, Eastern Cape

SELECTED PROJECT EXAMPLES

Freshwater Ecological Assessments

- Freshwater ecological assessment as part of the water use authorisation relating to stormwater damage of a tributary of the Sandspruit, Norwood, Gauteng province.
- Wetland verification as part of the environmental assessment and authorization process for the proposed development in Crowthorne extension 67, Gauteng province.
- Freshwater assessment as part of the section 24g rectification process for unauthorised construction related activities that took place on erf 411, Ruimsig extension 9, Gauteng province
- Baseline aquatic and freshwater assessment as part of the environmental assessment and authorisation process for the N11 Ring Road, Mokopane, Limpopo Province
- Wetland Resource Scoping Assessment as Part of The Environmental Assessment and Authorisation Process for The Kitwe TSF Reclamation Project, Kitwe, Zambia
- Wetland delineation as part of the environmental assessment and authorization process for the proposed development in Boden Road, Benoni, Ekurhuleni Metropolitan Municipality, Gauteng Province.

Soil, Land Use and Land Capability Assessments

- Soil, Land Use and Land Capability Assessment as part of the environmental assessment and authorisation process for the proposed Witfontein Railway Siding Project Near Bethal, Mpumalanga Province
- Soil, Land Use and Land Capability Assessment as part of the environmental assessment and authorisation process for the proposed Heuningkranz Mine, Postmasburg, Northern Cape Province

Hydropedological Wetland Impact Assessments

- Hydropedological Assessment as Part of The Environmental Assessment and Authorisation Process for the proposed Vandyksdrift Central Dewatering Project
- Hydropedological Assessment for the Proposed Evander Gold Elikhulu Tailings Storage Facility (TSF) Expansion, Mpumalanga Province
- Hydropedological Assessment as part of the environmental assessment and authorisation process for the proposed Palmietkuilen Mine, Springs, Gauteng Province
- Hydropedological Assessment as part of the environmental assessment and authorisation process for the proposed Uitkomst Colliery Mine expansion, Newcastle, KwaZulu-Natal Province

Soil Rehabilitation Assessments

- Soil rehabilitation plan, a water resource assessment and develop a management plan in support of the water use licence for the Driefontein operations, Carletonville, Gauteng